UNIVERSITY OF SWAZILAND
SUPPLEMENTARY EXAMINATION, JULY 2014

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER:	**BASIC ELECTRONICS**
COURSE NUMBER:	**EE221**
TIME ALLOWED:	**THREE HOURS**

INSTRUCTIONS:

1. There are five questions in this paper. **Answer any FOUR questions.**
2. Each question carries 25 marks.
3. Marks for different sections are shown on the right hand margin.
4. Show the steps clearly in all your calculations. This is because marks may be awarded for method and understanding, even if a final answer is incorrect.
5. If you think not enough data has been given in any questions you may assume reasonable values and state those assumptions.
6. A sheet containing useful formulae and other information is attached at the end.

THIS PAPER IS NOT TO BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

THIS PAPER HAS SEVEN (7) PAGES INCLUDING THIS PAGE

QUESTION 1 ***(25 marks)***

(a) Briefly explain the differences between each of the following terms as used in the description of the operation of pn-junctions:

(i) Intrinsic and extrinsic material *(2 marks)*

(ii) Electron and hole flow *(2 marks)*

(iii) p-type and n-type material *(2 marks)*

(iv) Majority and minority carriers *(2 marks)*

(b) If the current in a pn-junction diode is increased by a factor of 10 show that the forward voltage drop of the diode increases by $2.3nV_T$. *(5 marks)*

(c) In the diode-resistor circuit shown in Fig. Q1c, find the forward current flowing in diode D_2. *(7 marks)*

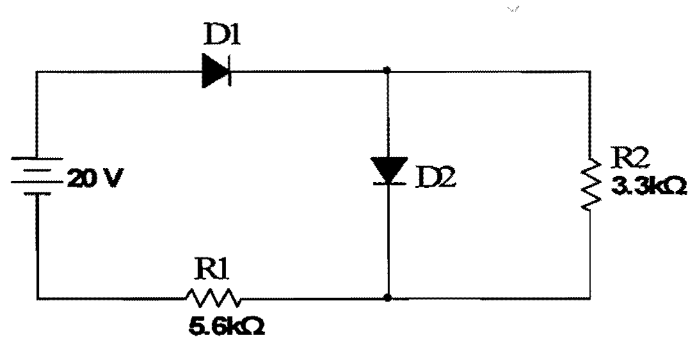

Fig. Q1c

(d) In the zener diode circuit shown in Fig.Q.1d, find the current flowing in the zener diode. *(5 marks)*

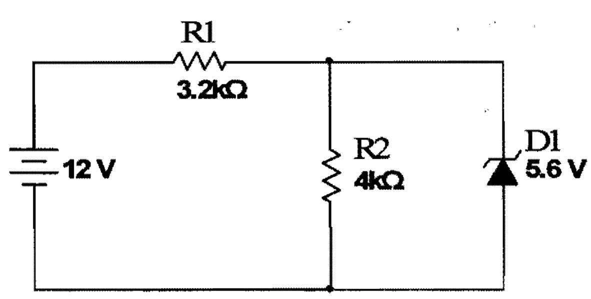

Fig. Q1d

QUESTION 2 ***(25 marks)***

(a) The diode circuit shown in Fig. Q2a is supplied with an a.c. voltage of $10\sin\omega t$ V.

(i) By drawing the equivalent circuit for each half cycle of the source voltage, obtain and sketch the voltage across the load resistor R_L. *(3 marks)*

(ii) What is the average voltage across the load resistor? *(1 mark)*

(iii) What is the peak inverse voltage appearing across each of the diodes? *(1 mark)*

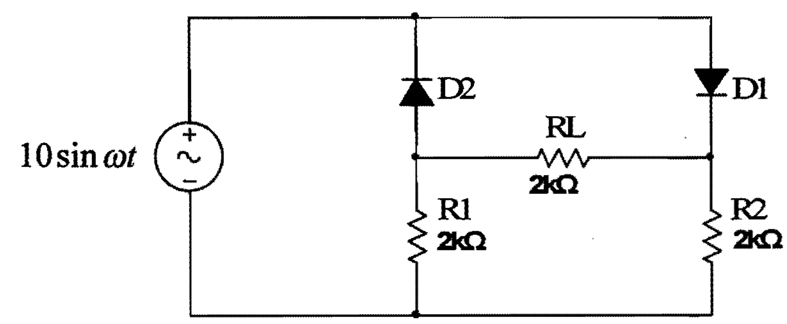

Fig. Q2a

(b) The circuits in Fig.Q2b(i) and Fig.Q2b(ii) are supplied with a.c. voltages $V_S = V_m \sin\omega t$. Obtain, giving your reasons, the expressions for the output voltages marked V_{o1} and V_{o2}. *(5+5 marks)*

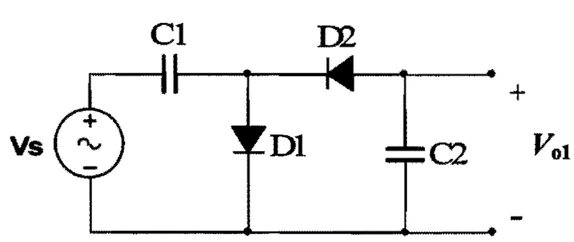

Fig.Q2b(i)

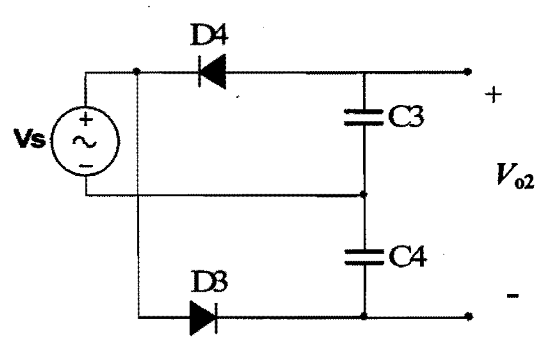

Fig.Q2b(ii)

(c) A full-wave bridge rectifier is fed from an a.c. supply of $24\sqrt{2}\sin(100\pi t)$ volts. The bridge supplies a load of 150 Ω in parallel with a capacitor 4700 μF. Assuming that the diodes used in the bridge are ideal, determine:

(i) the peak-to-peak ripple voltage in the load. *(3 marks)*

(ii) the average load voltage . *(3 marks)*

(iii) the peak current in the diodes when they are conducting.. *(4 marks)*

QUESTION 3 ***(25 marks)***

(a) Given that the transistor used Fig. Q3a has current gain β of 120, find the values of Rb and Rc needed to bias the transistor at $V_{CE} = 6$ V and $I_C = 3$ mA. *(8 marks)*

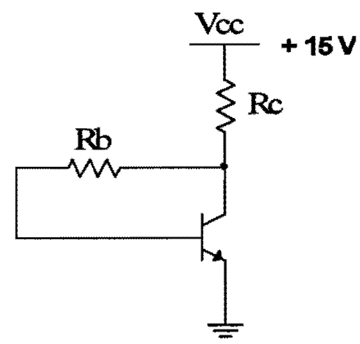

Fig.Q3a

(b) The transistor used in Fig.Q3b has $\beta = 150$. Obtain the values of I_C, V_{CE} and V_{CB}. *(12 marks)*

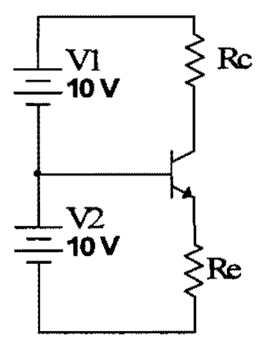

Fig.Q3b

(c) In what mode is the transistor in Fig.Q3c operating. Give reasons for your answer. *(5 marks)*

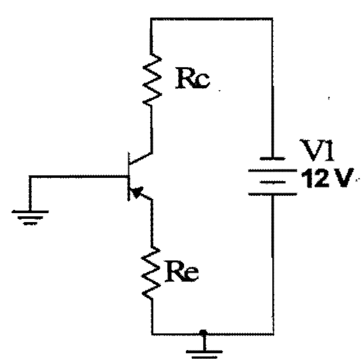

Fig.Q3c

QUESTION 4 ***(25 marks)***

Consider the circuit shown in Fig.Q4. You are given that the transistor used has $\beta = 180$ and $V_A = 50$ V.

(a) Perform d.c. analysis to find the operating point, I_C and V_{CE}, of the transistor.

(10 marks)

(b) Assuming that the capacitors used are very large, perform a.c. analysis to find the gain v_o / v_s of the circuit.

(15 marks)

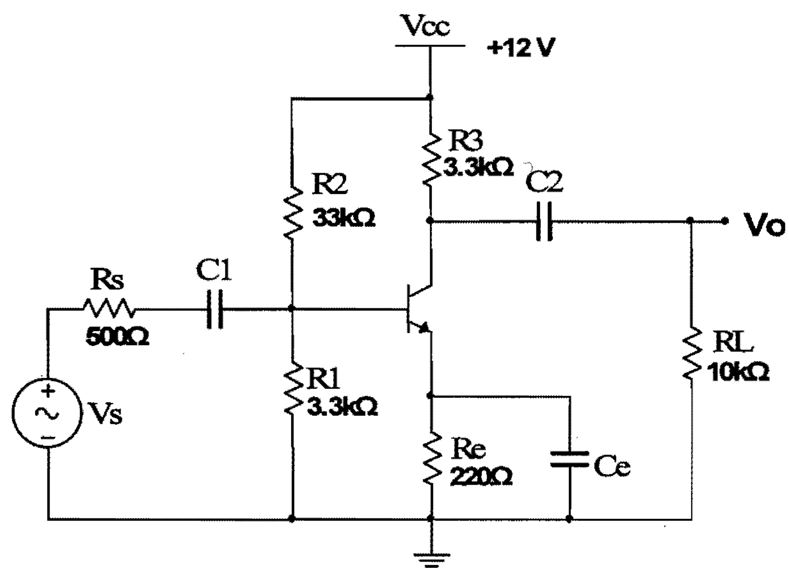

Fig. Q4

QUESTION 5 ***(25 marks)***

(a) The circuit in Fig. Q.5a is implemented using a variable resistance (potentiometer) R_2. What range of values of output voltage Vo are obtained as the potentiometer is adjusted?

(6 marks)

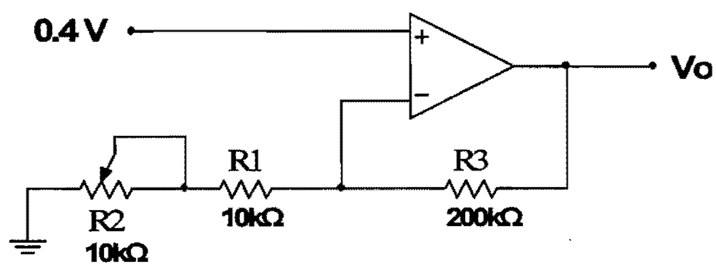

Fig. Q5a

(b) The opamp circuit shown in Fig. Q.5b is fed with voltages of +25 mV and -25 mV. Calculate the values of the output voltages V_{o1} and V_{o2}.

(10 marks)

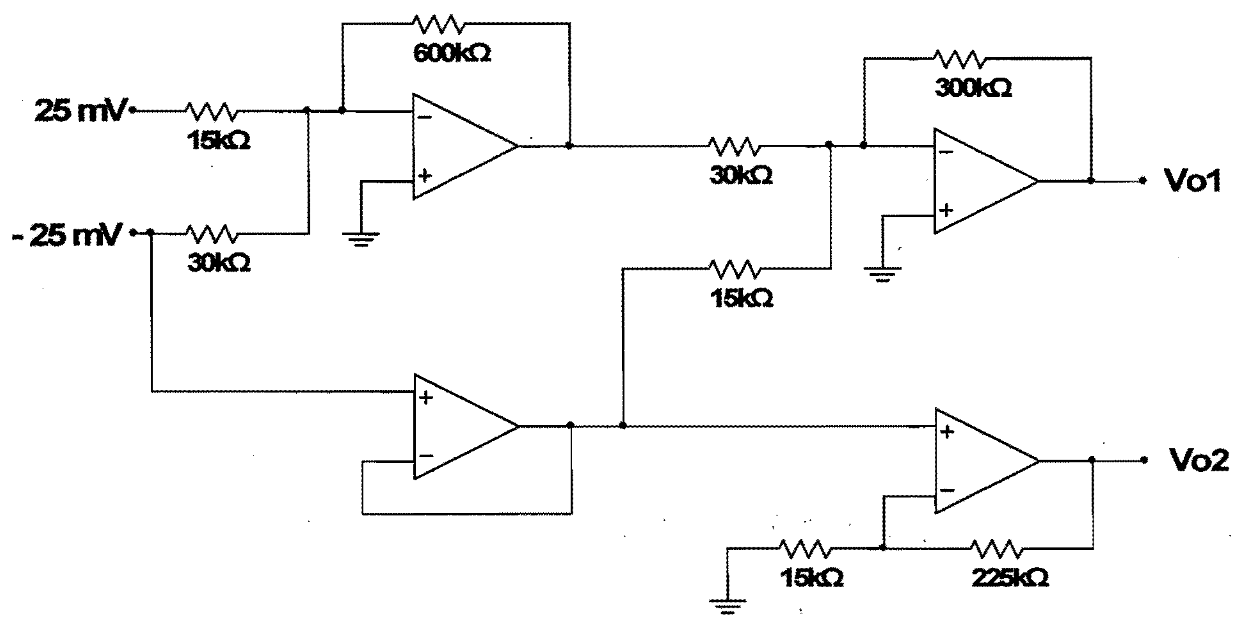

Fig. Q5b

(c) A triangular wave signal has a frequency of 500 Hz and amplitude ±1 V. Design an opamp-based circuit to change this signal into a square wave varying between ±5 V. Assume that you have available capacitors of values 22 nF, 33 nF and 47 nF. *(9 marks)*

USEFUL INFORMATION AND FORMULAE

1. **E12 Range: 10 12 15 18 22 27 33 39 47 56 68 82**

2. **Diode:** $i_D = I_S\left(e^{\frac{v_D}{nV_T}} - 1\right) \approx I_S e^{\frac{v_D}{nV_T}}$

3. **BJT:** $i_C = \alpha I_S\left(e^{\frac{v_{BE}}{V_T}} - 1\right)\left(1 + \frac{v_{CE}}{V_A}\right)$

4. **Rectification:**

$$V_r = \frac{V_m T_p}{R_L C}$$

$$\theta_c = \sqrt{\frac{2V_r}{V_m}}$$

$$i_{Dave} = \frac{V_m}{R_L}\left(1 + \omega T_p \sqrt{\frac{2V_m}{V_r}}\right)$$

$$i_{Dmax} = \frac{V_m}{R_L}\left(1 + 2\omega T_p \sqrt{\frac{2V_m}{V_r}}\right)$$

5. **Unless otherwise stated, assume that $V_{BEon} = 0.7$ V , $V_{CEsat} = 0.2$ V and $V_T = 25$ mV .**

6. **Unless otherwise stated assume that opamps are ideal.**